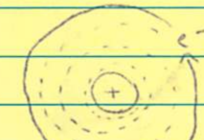
10-27-05 "Chpt 4 Test starts Here"

Arrangements of e^-



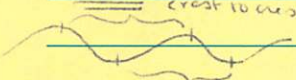
- Rutherford → found the nucleus — wrong idea about model of an atom.

reasons for P.[?] being wrong...

① – [?] model → shows e^- crashing into the nucleus
  – doesn't explain why e^- is so far out.
  ↳ b/c opposite charges attract.

② doesn't explain reactivity.

- waves — wave length (λ) [lamda] → distance from crest to crest or trough to trough
  → units → m, nanometers (nm)
  - $1\ m = 1 \times 10^{9}\ nm$
  - $1\ nm = 1 \times 10^{-9}\ m$



– frequency (ν) [nu] – how often the wave repeats itself in a second.
  → units: $\frac{cycles}{sec} = Hz$; $\frac{1}{s}$

– speed (c) – how fast the wave is going

☆ → $\boxed{c = \lambda\nu}$ → units: $\frac{m}{s}$

$\frac{m}{s} = m \cdot \frac{1}{s}$

- $\nu = \frac{c}{\lambda}$

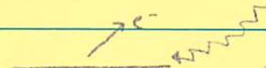
- waves – transmit E → sound E
  → light E (electromagnetic spectrum)
- light is part of the Electromagnetic (EM) Spectrum

Wave theory → • $c = \lambda\nu$; for all EM radiation → $c = 3.00 \times 10^{8}\ \frac{m}{s}$
  ↳ inverse proportions [as one goes ↑, other goes ↓]

- Two EXCEPTIONS to Wave Theory

  1) hot metals glowing – physics says EM radiation given off should be in the infra red range (IR).
    – also it was calculated to be ∞

  2) photoelectric effect – certain metals emit electrons when light shines on them / a minimum ν.

  ex. Cs 

  [reason behind solar panels]

Ch4 HMWK Read Ch4

Pg ~~[?]~~ 97 Q 1,5

116 Q 4,5

118 Rev Con 8,10

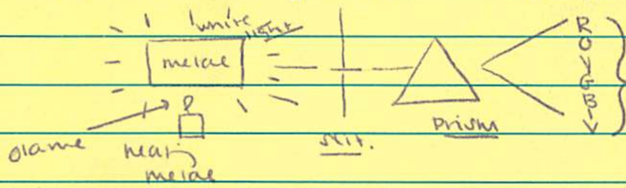
119 Q 23,24,30,32

Pg 120 Q 43

10-28-05

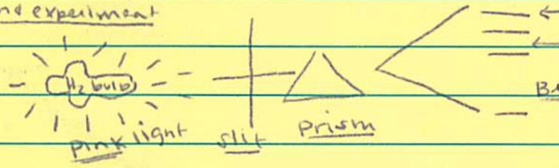
1st experiment

• Max Planck - worked with heating metals & analyzing the light.



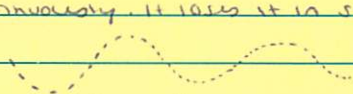
} continuous spectrum - all wave lengths are visible.
[white light → showing all colors there]

2nd experiment



• Planck's deductions

① Hot matter doesn't lose E continuously. It loses it in specific amounts or packets called quanta (pl.) [quantum (sing.)]



→ quanta - so close → that it looks like it's continuous.

- idea → simulate carpet → looks flat
- as one gets closer → see all flaws.

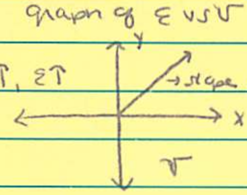
② E is like matter. It comes in packets. [groundbreaking statement]

③ Einstein called quanta light → photons

④ Each light in B-L spectrum is a quantum of E.

⑤ Planck finds a direct proportion b/w E of light & ν

graph of E vs ν



as ν↑, E↑

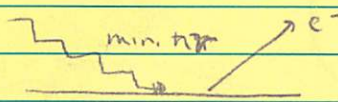
$E \propto \nu$

→ slope is constant [Planck's constant (h)]

☆ $h = 6.62 \times 10^{-34}$ J·s (joules · sec.s)

$E = h\nu$

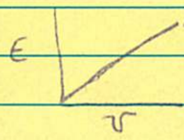
$[J = Js \cdot \frac{1}{s}]$



=> min. E

11-01-05

- Planck



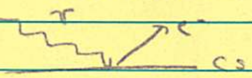
[J = [illegible] $\frac{1}{s}$] (J·S)

$E = h\nu$

↳ Planck's constant $= 6.62 \times 10^{-34}$ J·S

- explanation of why hot metal glows:
  - problem – E being given off by hot metals was thought to be infinite?
    → b/c w/ so many waves given off → ∞
  - solution: 1) b/c so many ν of light possible (continuous spectrum) it appeared to be infinite.
    2) $h \to 6.62 \times 10^{-34}$ J·S → soo small
    → also appears to be ∞ b/c scale is sooo small (10^{-34})
    [carpet analogy]

- Photoelectric effect



↳ light at a minimum ν would eject an e⁻ ⇒ min ν ⇒ min E.
- once the E is ~~released~~ reached, e⁻ can be ejected. [analogy to pushing a person over]

Application of Equations

- $E = h\nu$

  E = Energy (J)

  h = Planck's – 6.62×10^{-34} J·S ☆

  ν = frequency ($\frac{1}{s}$; Hz)

- $c = \lambda\nu$

  c = speed = for electromagnetic (EM) radiation = 3.00×10^{8} $\frac{m}{s}$ ☆

  λ = wave length (m, nm = 1 m = 1×10^{9} nm) ☆

- $\nu = \frac{c}{\lambda}$ · $\nu = \frac{E}{h}$

  so... $\frac{c}{\lambda} = \frac{E}{h}$ → $E = \frac{ch}{\lambda}$ ☆

- practice problem → the E of a wave is 7.53×10^{-19} J → wave length?

  $E = \frac{ch}{\lambda}$; $E = 7.53 \times 10^{-19}$ J

  $c = 3.00 \times 10^{8}$ $\frac{m}{s}$

  constants ↙ $h = 6.62 \times 10^{-34}$ J·S

  $\lambda = ?$

  ↳ $\lambda = \frac{ch}{E}$

  $\lambda = \frac{(3.00 \times 10^{8} \frac{m}{s})(6.62 \times 10^{-34} J \cdot s)}{(7.53 \times 10^{-19} J)} = 2.64 \times 10^{-7}$ m $\cdot \frac{1 \times 10^{9} nm}{1 m} = 264$ nm

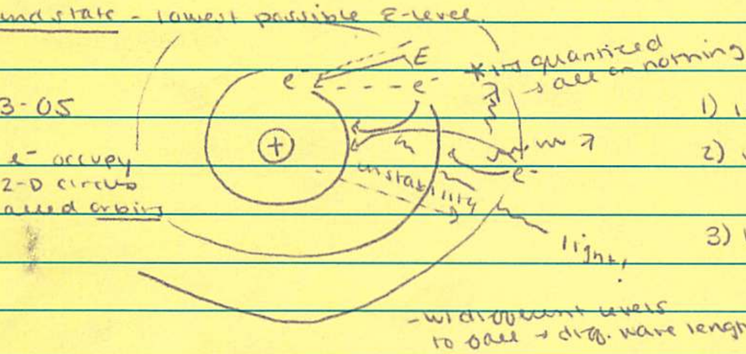
  ↑ need it in nanometers ☆

11-02-05

• Bohr's Model of the H atom [incorrect]
↳ analyzed the BL-spectrum of H - said the atom of quantized (had specific E-levels) → ex to stairs

• e^- → exists only in specific E-levels.
- when E is absorbed by the e^- → it becomes excited & jumps to a higher E-level (the excited state)
- higher the E-level => more unstable.
- & when they're unstable → they fall back down to lower E-levels.
• LCE → gives off the E difference as light [seen as lines in the BL-spectrum]

• ground state - lowest possible E-level.



11-03-05

1) if e^- stay in one orbit, no E gained or lost
2) if E is added => e^- jumps to a higher E-level
→ excited state
* unstable
3) if e^- falls to lower E-level, E is given off as light (seen as ~~tra~~ a line on the BL-spec.)

- Bohr → predicted lines in UV section.
* couldn't match BL spec. for He.
* only worked for H.

=> Bohr's model is wrong
1) model wouldn't support atoms w/ more than one e^-.
→ most elements BL spec. wouldn't match w/ predicted E levels
2) offered no explanation of chemical reactivity (whole pt. of chemistry)

• Louis de Broglie --> what if e^-s behave as waves not particles?
- waves → are in a confined space & have a specific E

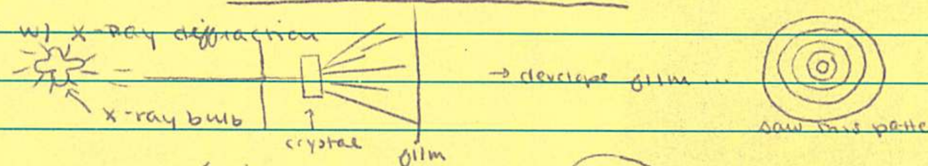
$E = h\nu$, $E = \frac{hc}{\lambda}$

- e^-s are in a confined space (orbits, E-levels) & have a specific E
→ so e^-s can behave like waves.

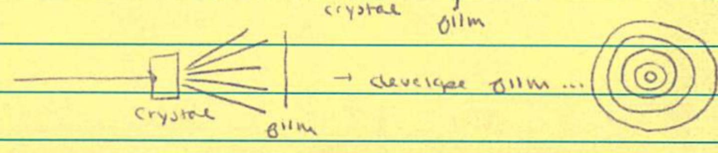
11-04-05

• de Broglie [review from yesterday] - waves in a confined space & has a specific E
- e^-s are in a confined space (E levels) & also have specific energy.
=> e^-s may behave like waves

- proved his hypothesis w/ X-ray diffraction
• takes X-rays



• beam of e^-s



=> proved e^-s behave like waves!!

- since the scattering patterns are the same => e^-s behave like waves

• wave-particle duality → whenever (one has) decreasing amounts of matter & E are measured they appear indistinguishable.

$[E = mc^2]$

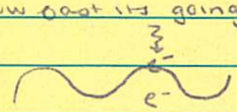
problem...

waves don't travel in a circle...

11-04-05

- Schrödinger - derived a wave equation correctly
  - described the behavior of a wave in 3D.

- Heinsenburg - uncertainty principle - if an e^- is a wave, one can not simultaneously know where an e^- is & how fast its going.



- either move the e^- down b/c the mass is so small
- or would slow down e^- → won't know speed.

BUT
- do know the area w/ the highest probability of finding an e^-

- Quantum model vs Bohr's model ...

vs.
[contrast]

Quantum model	Bohr's model
• e^-s are in orbitals (3D area that indicates the location/area of the best probability of finding an e^-)	• e^- in orbits (2D circular paths) ⟹ can pin pt. the location of an e^-
• e^-s → behave like waves	• e^- → treated as particles
✱ can't pin pt. the e^-	

- Similarities ...
  - both have idea of E-levels, ground state, excited state
    - E can be absorbed or given off. as e^- change E-levels.
  - distance of 1st E from the nucleus is the same in both models.

- Three Assumptions of the Quantum model (Q-model)
  1) e^-s behave like waves, not particles
  2) wave particle duality - decreasing amounts of matter & E → indistinguishable. (justifies #1)
  3) will never be able to pin pt. an e^-'s location → only find area w/ the highest probability

11-08-05 Quantum Model [4 parts]

① principle quantum # (n) = tells which E-level e⁻s are in. → range from 1 to ∞ (7) theoretically.
- from discovery → 7.

- periodic table → aligned perfectly w/ quantum model.
→ each period is an E-level.

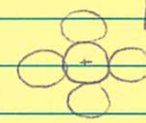
② orbital quantum # (AKA angular momentum Q-#) (l) - tells which orbit e⁻ is in.

l = s, p, d, f
(different orbitals.)

③ orbitals --> charts

every E-level has one. ↓

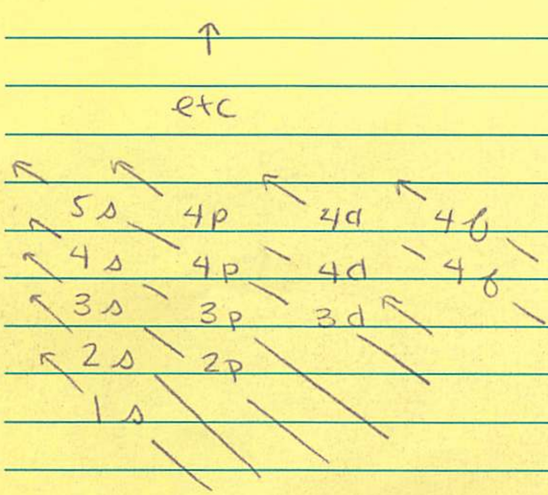
orbitals	# of parts / # of suborbitals	# of e⁻ per suborbital	total # of e⁻	shape
• s	1	2e⁻	2e⁻	sphere
• p	3	2e⁻	6e⁻	peanut/propeller shape
• d	5	2e⁻ (always have to be paired)	10e⁻	
• f	7	2e⁻	14e⁻	

→ max 100% in atom for s & p orbital ∴  + z-axis of p orbital

④ e⁻ spin → moving charged particles - will spin on an axes.
⟹ provides magnetism → all have to be spinning in same direction.

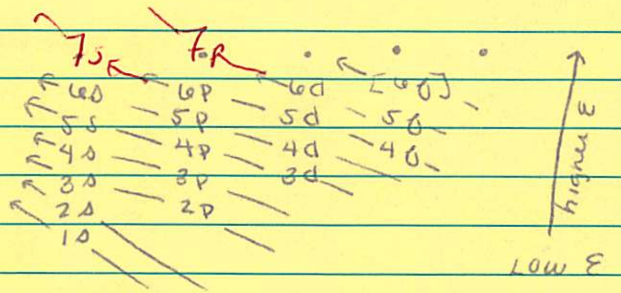
• 3 Guides for filling order

1) Aufbau principles - orbitals are filled w/ e⁻s from lowest to highest E.

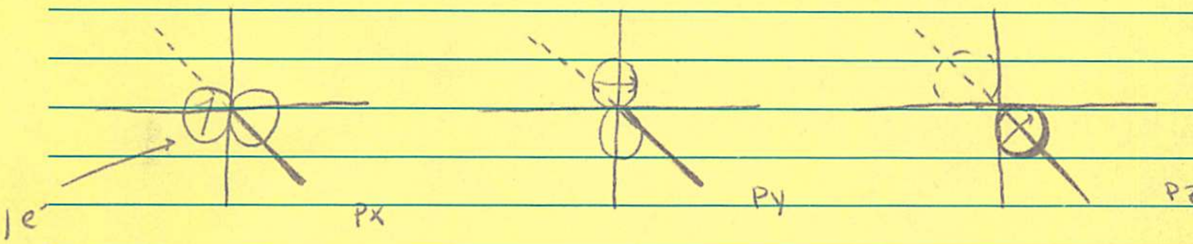


11-10-05

Filling Order



• Hund's Rule → 1e⁻ per suborbital before doubling.



• Pauli Exclusion Principle → no $2e^{-}$s can have the same 4 Q#'s

[no $2e^{-}$s can be in the same place at the same time]

E⁻ Configuration Notation

• basic format → $nl^{\#e^{-}}$ (# of e⁻ in orbital → can't exceed max. #)

principle Q#/ E-level [1-7]

orbital (s, p, d, f) → 2, 6, 10, 14

ex. $_{6}C$ → 6e⁻ : $1s^2 2s^2 2p^2$

\# of protons = # of e⁻s in an atom [b/c neutral]

→ corresponds w/ periodic table!

ex. $_{7}N$ → 7e⁻ : $1s^2 2s^2 2p^3$

ex. $_{15}P$ → 15e⁻ : $1s^2 2s^2 2p^6 3s^2 3p^3$

Orbital Notation (shows which orbitals filled & how e⁻s are paired & spinning)

• basic format

↑↓ } show e⁻s → spin up or down

orbital → ___

nl

principle Q#/ E-level

orbital (s, p, d, f)

[2 e⁻s]

★ don't use arrows only! shows pair of e⁻s

ex ↑↓ (1s) [only 1 pair]   ↑↓ (2s) ↑ ↑ __ (2p) [not 3 pairs]

→ for $1s^2 2s^2 2p^2$

b/c → Pauli Exclusion Principle → can't have ↑↑

ex. $1s^2 2s^2 2p^3$ [N's configuration] → ↑↓ (1s) ↑↓ (2s) ↑ ↑ ↑ (2p)

11-14-05

<u>$\acute{E}$ dot configuration</u>

- <u>valence e^-</u> → outermost s & p e^- → max: 8 e^{-s}
  - ↓ highest E-level

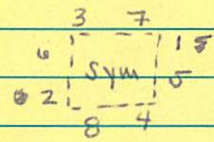
ex. N → $1s^2\ 2s^2\ 2p^3$ → 2 + 3 → **5 val. e^-**

ex. V → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$ → **2 val. e^-**

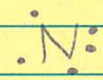
- on periodic table → groups. [few exceptions]

<u>E^- dot</u> → dot for each valence e^- around symbol

ex.



ex.



} show how its paired

<u>Noble Gas Notation</u>

ex V → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$

[Ar] $3d^3\ 4s^2$

11-15-05 → Cu, Ag & Au → all have 1 val. e-

Exceptions

• Cu exception → $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 4s^2$ [Ar]

↳ ends $3d^9$ [9th spot in D-block]

noble gas notation

$[Ar] 3d^9 4s^2$

orbital notation [Ar] ⥮ ⥮ ⥮ ⥮ ↿ (3d) ⥮ (4s) → [Ar] ⥮ ⥮ ⥮ ⥮ ⥮ (3d) ↿ (4s)

one e- drops down & fills the d orbital => makes it stable.

↳ $[Ar] 3d^{10} 4s^1$

~~• also happens in~~ Ag & Au.

[d-orbital → much higher E than s orbital]

• also w/ Cr & Mo.

• Cr → $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^2$ (first part = [Ar.])

[Ar] ↿ ↿ ↿ ↿ _ (3d) ⥮ (4s)

1e- drops down giving 1e- in each suborbital [following Hund's rule] → less orbital repulsion → each orbital has 1 e-.

→ $[Ar] 3d^5 4s^1$ [same for Mo]